



**EDGEWOOD**  
CHEMICAL BIOLOGICAL CENTER  
U.S. ARMY SOLDIER AND BIOLOGICAL CHEMICAL COMMAND

ECBC-TR-004

**DOMESTIC PREPAREDNESS PROGRAM: LIQUID SULFUR MUSTARD AND  
SARIN CHALLENGE/VAPOR PENETRATION SWATCH TESTING  
OF ILC CHEMTURION SUIT  
MODEL 13**

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February 1999

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Aberdeen Proving Ground, MD 21010-5424

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## Preface

The work described in this report was authorized under the Expert Assistance (Personal Protective Equipment Evaluation) Program for the U. S. Army Edgewood Research, Development and Engineering Center (ERDEC)\* Program Director for Domestic Preparedness. This work was started in January 1998 and completed in February 1998.

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\* Now known as the U.S. Army Edgewood Chemical Biological Center (ECBC).

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**DOMESTIC PREPAREDNESS PROGRAM: LIQUID SULFUR MUSTARD AND  
SARIN CHALLENGE/VAPOR PENETRATION SWATCH TESTING  
OF ILC CHEMTURION SUIT  
MODEL 13**

**1. INTRODUCTION**

Under the Domestic Preparedness (DP) Expert Assistance (Personal Protective Equipment (PPE) Evaluation) Program, the U. S. Army Edgewood Research, Development and Engineering Center (ERDEC)\* was tasked to perform testing of swatches taken from commercially-available Level A suits currently being used by emergency responders from cities involved in this program. The testing was performed by the Design Evaluation Group, Surety Team, Methodology, Instrumentation and Test Office, Engineering Directorate. The test procedure was jointly developed and agreed upon by ERDEC and the U. S. Army Natick, Research, Development and Engineering Center (NRDEC) (written communication, M. Chin, NRDEC, 1 May 97).

**2. MATERIALS AND METHODS**

**2.1 Suit Description.**

The Chemturion suit was manufactured by ILC Dover, Incorporated, (Frederica, DE) and was blue in color. The model number was 13. The suit did not come with gloves. Figure 1 is a digital photograph of the label found inside the suit.

**2.2 Swatch Preparation.**

The day before testing was scheduled to begin, the suit was picked up from Mask Issue and transported to the laboratory. The suit was folded up for transport and was hung on a hanger once in the laboratory. The suit was stored this way during and after testing.

The swatch locations to be sampled were given in the PPE Test Team Work Contract for Level A Ensembles (written communication, R. Belmonte, Engineering Directorate, ERDEC, 25 June 1997). These swatch sampling locations were listed as suit material (SM), suit seam (SS), visor material (VM), zipper/suit material seam (ZP), glove (GL), and visor material/suit material seam (SV). The suit pass through could not be sampled because it could not be made flat to fit in a permeation cell. The swatches were normally cut the day before testing and conditioned overnight at the test conditions. For a Monday test, swatches were cut Friday and conditioned over the weekend. Normally, the swatches would be laid in the environmental cabinet for conditioning.

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\* Now known as the U.S. Army Edgewood Chemical Biological Center (ECBC).

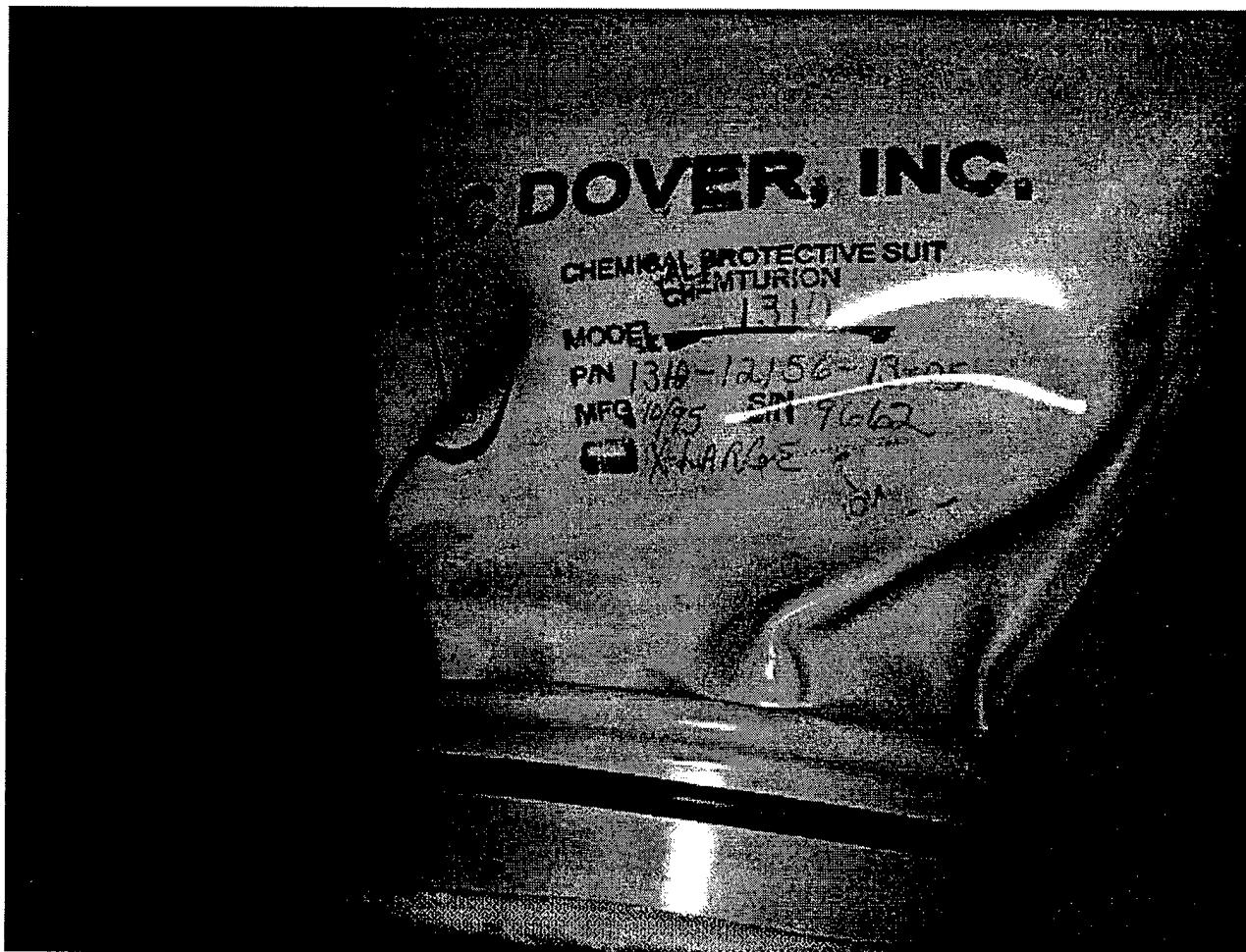


Figure 1. ILC Chemturion Label

The swatches were numbered in accordance with the PPE Test Team Work Instructions (written communication, R. Belmonte, Engineering Directorate, ERDEC, 11 June 1997); for example LC-ILC-SM-01, etc. All swatches were cut in triplicate, one at a time on a sample press. The swatch diameter was 2 in.

The reference material was 80-mil silicone, using the M45 mask formulation, prepared by Malcolm Little of the M45 mask team. Preparation and conditioning were the same as for the suit swatches.

### 2.3        Test Procedure.

The procedure agreed upon by ERDEC and NRDEC was derived from the report entitled, "Permeation and Penetration Testing of Air Permeable, Semi-permeable and Impermeable Materials with Chemical Agents or Simulants (Swatch Testing)" dated 3 March 1997. The Modified Static Diffusion Procedure is found in Appendix A of this

report. Subsequent to the agreement, ERDEC personnel determined that the usage of the 80-mil silicone did not meet the definition of a positive control. The silicone swatches were used as an indication of agent vapor permeation. Equipment and schedule limitations prevented the use of negative controls. The terminology of the test procedure was not modified to reflect these changes.

The TOP permeation cell was used and a digital photograph of one is given as Figure 2.

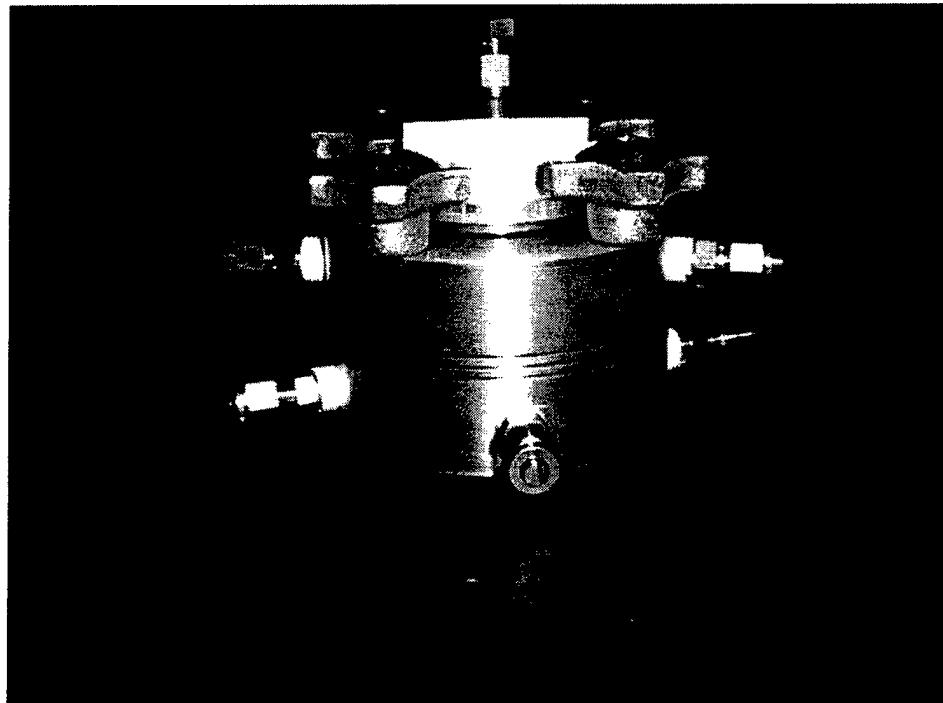


Figure 2. TOP Permeation Cell

The remainder of the test apparatus consisted of:

- Plastic environmental cabinet with sliding doors containing a permeation cell rack, circulating blower, and heat source (Figure 3).
- Flow/temperature/relative humidity control system; (Miller-Nelson Research Corporation, Monterey, CA) model HCS-410.
- Flow control system; (Tylan General Incorporated, Torrance, CA) Dynamass model FM-8.
- Mass flow controllers; (Tylan General Incorporated, Torrance, CA) model FC-260.
- Calibrated Vaisala humidity and temperature indicator.

- MINICAMS, serial number 2362, and Stream Selection System (CMS Research Corporation, Birmingham, AL), illustrated in Figure 4.

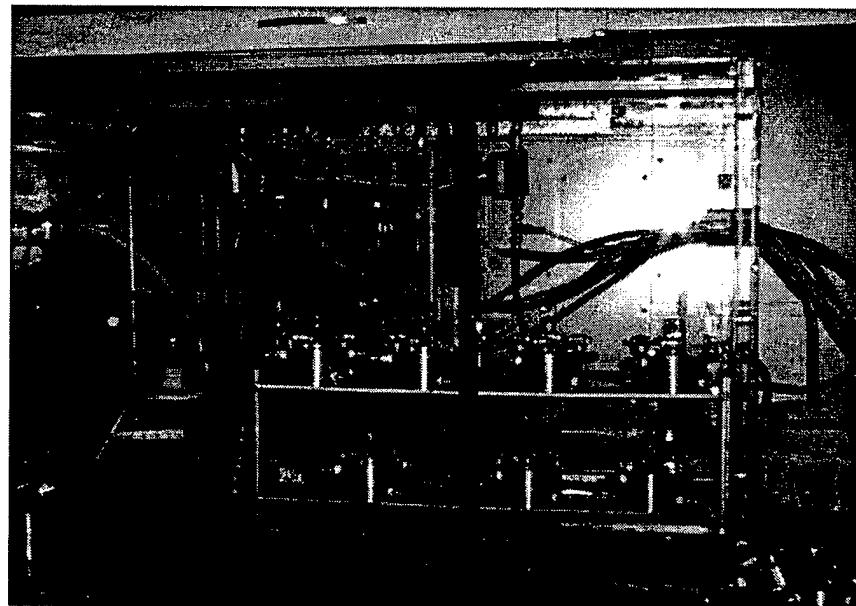


Figure 3. Environmental Cabinet

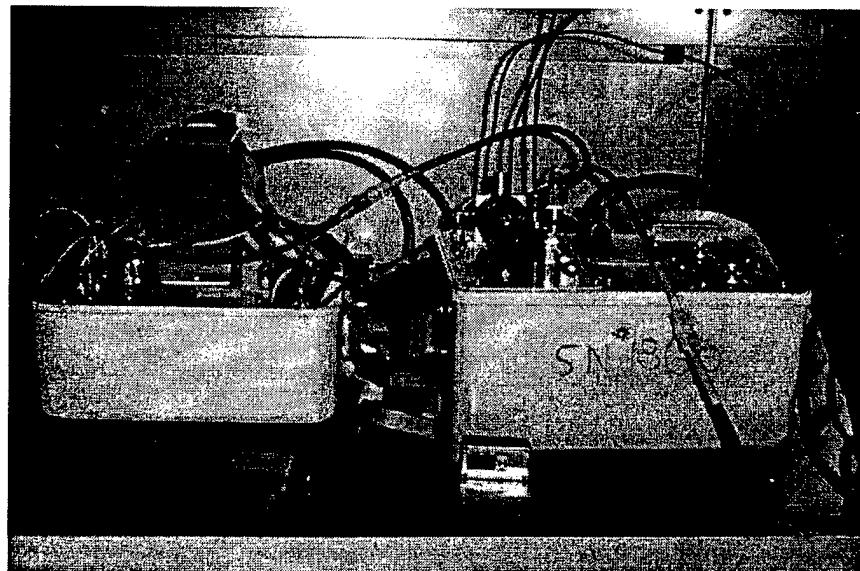


Figure 4. MINICAMS and Stream Selection System

### 3. RESULTS AND DISCUSSION

#### 3.1 HD Results.

The HD permeation results are given in Appendix B as Tables B-1 through B-6. Average elapsed time was not used. The actual time that each swatch was sampled by the MINICAMS is shown.

The MINICAMS minimum detection limit was 1.0 ng for all test days. The suit material swelled where the HD droplets were placed. Cumulative permeation was highest for the suit material and suit seam swatches.

The average temperature was 94.7 °F, and 23.0% RH was the average for all tests. Test temperatures were greater than 90 °F due to a malfunction in the laboratory heating system, which caused the room temperature to be elevated, and the lack of a cooling capability in the test apparatus. The first MINICAMS cycle for each swatch was taken before agent was applied. This cycle served as an indication that no agent vapor was present prior to the start of the test. Negative control and positive control swatches were not used due to budget and schedule limitations.

### 3.2 GB Results.

The GB permeation results are given in Appendix C as Tables C-1 through C-6.

The MINICAMS minimum detection limit was 0.4 ng for all test days. There were no visible effects on any of the materials from GB exposure. Cumulative permeation was highest for the zipper/material interface and the suit/visor interface swatches; lowest for the visor and outer zipper swatches.

The average temperature was 92.7 °F and 20.1% RH was the average for all tests. Test temperatures were greater than 90 °F due to a malfunction in the laboratory heating system, which caused the room temperature to be elevated, and the lack of a cooling capability in the test apparatus. The first MINICAMS cycle for each swatch was taken before agent was applied. This cycle served as an indication that no agent vapor was present prior to the start of the test. Negative control and positive control swatches were not used.

### 3.3 Material Thickness.

After the HD and GB testing was completed, thickness measurements of the suit material and visor material were made. A swatch of material was cut from the suit immediately adjacent to the area from which the agent swatches were taken. Twenty-four thickness measurements were taken on each swatch using an Ames dial comparator (B. C. Ames Company, Waltham, MA). The average thickness of the suit material swatch was 0.038 in., and the average thickness of the visor material swatch was 0.038 in. No average thickness of the gloves was done due to the absence of gloves.

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**APPENDIX A**  
**MODIFIED STATIC DIFFUSION PROCEDURE**

## **MODIFIED STATIC DIFFUSION TEST**

This test procedure was adapted from the "Semipermeable and Impermeable Materials Static Diffusion Penetration Testing (Liquid Agent Challenge/Vapor Penetration; delta p = 0, Single Flow Test) given in Test Operations Procedure (TOP) 8-2-501 dated 3 Mar 97.

The following procedure will be used:

Upon receipt of a suit, all available information concerning the suit will be recorded; date of manufacture, lot number, serial number, materials of construction, etc.

From each suit, 3 ea 1 and 15/16 in. diameter material swatches will be taken for HD and a like number taken for GB. Depending upon the suit configuration, three seam swatches (same diameter) will be taken plus triplicate swatches of other flat components such as other seams, visor, gloves, booties, etc. for HD and an equal number for GB. Each swatch will be placed in an airtight bag and given a unique serial number which will be placed on the bag. A list of serial numbers will be kept with the swatches.

The environmental chamber will be controlled at a temperature of 90 +/- 2 °F, and the maximum achievable RH without occurrence of condensation (70% +/- 10% RH). The temperature and RH readings will be checked weekly with a calibrated meter. The test cell air will be drawn from the chamber air. There will be no system control and data acquisition system. The temperature and RH will be recorded in a computer file. Flow rates will be manually recorded. There will be no differential pressure monitoring since differential pressure gages of sufficient sensitivity are not available.

The TOP test cell will be used. When assembling, the cell lugs will be tightened by hand to finger tight. The flow rate beneath each swatch will be 1 L/min which will be controlled by a linear mass flow controller. The flows will be checked with a calibrated test meter weekly. Each test cell will be checked for leaks after assembly by connecting it to the vacuum source and checking that the inlet flow is the same as the outlet flow on the mass flow controller (cell lugs will be retightened if flows don't match).

The samples will serve as their own negative controls while being preconditioned overnight by being MINICAMS monitored. Eighty mil silicone will be used as a positive control for each test (six suit swatches and one silicone swatch).

Agents GB and HD will be used. The contamination density will be 10 g/m<sup>2</sup> (eight each 1 µl HD droplets or ten each 1 µl GB droplets). A robotic agent application system is not available. The agent will be applied using the click/touch method with a Hamilton repeating dispenser.

Seven swatches will be tested at once. MINICAMS with stream selection system will monitor vapor penetration with a 3-min cycle. There will be three blank sampling intervals following the control. Each swatch will be sampled once every 30 min. The MINICAMS will be standardized weekly.

The test length will be 24 hr.

The test cells and o-rings will be aerated between uses. No other cleaning method will be used.

The data to be reported are cumulative penetration (ng/cm<sup>2</sup>) versus average elapsed time (minutes) for each swatch. The average elapsed time is the sum of the elapsed time for swatch 1 and the elapsed time for swatch 6 divided by 2. All recorded data will be placed in laboratory notebooks and a technical report will be drafted at the conclusion of this effort.

For entry into the DP database, the data for each swatch will be reported as cumulative penetration for the first four sampling intervals (approximately 12, 42, 72, and 102 min), and at approximately 6, 12, 18, and 24 hr.

**Appendix A**

## **APPENDIX B**

### **HD TABLES**

Table B-1. ILC Chemturiion Suit Material vs. HD Liquid, 10 g/m<sup>2</sup>

Modified Static Diffusion Test, 27 Jan 98

Cumulative Penetration (ng/cm<sup>2</sup>)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	0	13	0	16	0
40	13	43	13	46	4
70	26	73	26	76	8
100	26	103	26	106	8
130	29	133	26	136	8
160	427	163	412	166	394
190	1206	193	1181	196	1165
220	1978	223	1948	226	1936
250	2753	253	2719	256	2710
280	3529	283	3494	286	3487
310	4311	313	4274	316	4268
340	5097	343	5055	346	5052
370	5882	373	5836	376	5836
400	6669	403	6622	406	6622
430	7458	433	7409	436	7411
460	8247	463	8194	466	8200
490	9038	493	8981	496	8990
520	9828	523	9768	526	9781
550	10616	553	10556	556	10571
580	11401	583	11342	586	11358
610	12188	613	12126	616	12145
640	12977	643	12913	646	12931
670	13767	673	13702	676	13720
700	14556	703	14487	706	14510
730	15344	733	15272	736	15299
760	16136	763	16061	766	16090
790	16931	793	16856	796	16882
820	17728	823	17651	826	17677
850	18525	853	18443	856	18471
880	19323	883	19235	886	19264
910	20121	913	20029	916	20059
940	20919	943	20824	946	20857
970	21719	973	21621	976	21657
1000	22519	1003	22418	1006	22460
1030	23321	1033	23218	1036	23264
1060	24126	1063	24017	1066	24066
1090	24933	1093	24814	1096	24868
1120	25737	1123	25615	1126	25670
1150	26538	1153	26417	1156	26471
1180	27341	1183	27219	1186	27276
1210	28151	1213	28025	1216	28090
1240	28970	1243	28843	1246	28913
1270	29800	1273	29670	1276	29740
1300	30634	1303	30499	1306	30570
1330	31467	1333	31328	1336	31421
1360	32299	1363	32158	1366	32271
1390	33128	1393	32982	1396	33097
1420	33955	1423	33806	1426	33923

Note: HD caused material to swell (raised bumps) where droplets were placed.

## Appendix B

**Table B-2. ILC Chemturon Suit Seam vs. HD Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 27 Jan 98**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	0	7	0
31	0	34	0	37	0
61	0	64	0	67	0
91	0	94	0	97	0
121	8	124	0	127	20
151	396	154	334	157	421
181	1156	184	1051	187	1185
211	1919	214	1819	217	1951
241	2684	244	2587	247	2717
271	3451	274	3360	277	3486
301	4223	304	4139	307	4259
331	4998	334	4920	337	5036
361	5775	364	5701	367	5813
391	6554	394	6483	397	6591
421	7333	424	7266	427	7372
451	8111	454	8050	457	8153
481	8890	484	8834	487	8934
511	9671	514	9617	517	9715
541	10452	544	10400	547	10496
571	11229	574	11183	577	11275
601	12006	604	11966	607	12055
631	12783	634	12751	637	12836
661	13561	664	13538	667	13617
691	14341	694	14324	697	14394
721	15120	724	15108	727	15174
751	15899	754	15895	757	15957
781	16682	784	16684	787	16742
811	17468	814	17476	817	17529
841	18256	844	18269	847	18318
871	19042	874	19061	877	19108
901	19828	904	19852	907	19898
931	20614	934	20645	937	20689
961	21403	964	21440	967	21480
991	22195	994	22236	997	22271
1021	22987	1024	23033	1027	23064
1051	23781	1054	23834	1057	23860
1081	24573	1084	24632	1087	24657
1111	25365	1114	25432	1117	25450
1141	26159	1144	26233	1147	26242
1171	26954	1174	27036	1177	27037
1201	27757	1204	27838	1207	27853
1231	28576	1234	28649	1237	28676
1261	29401	1264	29471	1267	29495
1291	30222	1294	30298	1297	30319
1321	31046	1324	31124	1327	31144
1351	31871	1354	31949	1357	31969
1381	32693	1384	32775	1387	32793
1411	33511	1414	33597	1417	33613

Note: HD caused material to swell (raised bumps) where droplets were placed.

## Appendix B

**Table B-3. ILC Chemturon Outer Zipper Material vs. HD Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 4 Feb 98**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	0	7	1
31	4	34	4	37	10
61	7	64	7	67	19
91	7	94	7	97	29
121	7	124	10	127	39
151	9	154	15	157	50
181	15	184	20	187	61
211	21	214	27	217	73
241	29	244	34	247	86
271	37	274	42	277	99
301	45	304	50	307	112
331	54	334	58	337	125
361	62	364	66	367	138
391	71	394	75	397	151
421	79	424	83	427	164
451	88	454	91	457	177
481	96	484	99	487	189
511	105	514	107	517	202
541	113	544	115	547	215
571	121	574	123	577	227
601	129	604	131	607	240
631	137	634	138	637	253
661	145	664	146	667	266
691	152	694	153	697	278
721	160	724	161	727	290
751	167	754	168	757	302
781	174	784	175	787	314
811	182	814	183	817	326
841	189	844	190	847	338
871	195	874	196	877	350
901	202	904	203	907	362
931	209	934	210	937	373
961	215	964	217	967	385
991	222	994	223	997	397
1021	228	1024	230	1027	408
1051	235	1054	236	1057	420
1081	241	1084	243	1087	432
1111	247	1114	249	1117	443
1141	254	1144	255	1147	455
1171	260	1174	262	1177	468
1201	267	1204	268	1207	480
1231	273	1234	275	1237	493
1261	280	1264	281	1267	507
1291	287	1294	288	1297	521
1321	295	1324	295	1327	535
1351	302	1354	302	1357	550
1381	310	1384	309	1387	565
1411	318	1414	316	1417	580

Note: HD caused material to swell (raised bumps) where droplets were placed.

## Appendix B

Table B-4. ILC Chemturon Zipper/Material Interface vs. HD Liquid, 10 g/m<sup>2</sup>

Modified Static Diffusion Test, 4 Feb 98

Cumulative Penetration (ng/cm<sup>2</sup>)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
7	1	13	0	16	1
37	10	43	0	46	7
67	19	73	0	76	12
97	29	103	0	106	17
127	39	133	0	136	24
157	50	163	0	166	34
187	61	193	0	196	50
217	73	223	0	226	73
247	86	253	0	256	104
277	99	283	0	286	143
307	112	313	2	316	190
337	125	343	4	346	246
367	138	373	6	376	309
397	151	403	10	406	378
427	164	433	15	436	453
457	177	463	19	466	533
487	189	493	23	496	615
517	202	523	27	526	700
547	215	553	31	556	791
577	227	583	36	586	888
607	240	613	40	616	986
637	253	643	44	646	1086
667	266	673	49	676	1187
697	278	703	53	706	1291
727	290	733	57	736	1396
757	302	763	62	766	1502
787	314	793	66	796	1610
817	326	823	71	826	1721
847	338	853	75	856	1833
877	350	883	80	886	1948
907	362	913	85	916	2064
937	373	943	90	946	2181
967	385	973	95	976	2300
997	397	1003	101	1006	2420
1027	408	1033	107	1036	2542
1057	420	1063	113	1066	2666
1087	432	1093	119	1096	2795
1117	443	1123	126	1126	2928
1147	455	1153	133	1156	3062
1177	468	1183	140	1186	3203
1207	480	1213	148	1216	3348
1237	493	1243	157	1246	3500
1267	507	1273	166	1276	3656
1297	521	1303	175	1306	3817
1327	535	1333	186	1336	3983
1357	550	1363	197	1366	4154
1387	565	1393	209	1396	4327
1417	580	1423	221	1426	4505

Note: HD caused material to swell (raised bumps) where droplets were placed.

## Appendix B

**Table B-5. ILC Chemturon Visor Material vs. HD Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 3 Feb 98**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	0	7	0
31	0	34	0	37	0
61	0	64	0	67	0
91	0	94	0	97	0
121	0	124	0	127	0
151	0	154	0	157	0
181	3	184	0	187	0
211	8	214	2	217	2
241	14	244	7	247	6
271	21	274	12	277	11
301	28	304	17	307	16
331	35	334	23	337	21
361	43	364	28	367	26
391	50	394	34	397	31
421	57	424	39	427	36
451	64	454	44	457	40
481	71	484	49	487	45
511	78	514	55	517	50
541	85	544	59	547	55
571	91	574	64	577	59
601	97	604	69	607	63
631	103	634	74	637	68
661	109	664	78	667	72
691	114	694	82	697	76
721	120	724	87	727	78
751	125	754	89	757	78
781	130	784	89	787	78
811	135	814	89	817	78
841	139	844	89	847	78
871	144	874	89	877	78
901	148	904	89	907	78
931	153	934	89	937	78
961	155	964	89	967	78
991	155	994	89	997	78
1021	155	1024	89	1027	78
1051	155	1054	89	1057	78
1081	155	1084	89	1087	78
1111	155	1114	89	1117	78
1141	155	1144	89	1147	78
1171	155	1174	89	1177	80
1201	155	1204	89	1207	84
1231	155	1234	89	1237	88
1261	155	1264	89	1267	93
1291	155	1294	89	1297	98
1321	155	1324	89	1327	104
1351	155	1354	89	1357	110
1381	155	1384	89	1387	116
1411	155	1414	89	1417	123

## Appendix B

Table B-6. ILC Chemturon Suit/Visor Interface vs. HD Liquid, 10 g/m<sup>2</sup>

Modified Static Diffusion Test, 3 Feb 98

Cumulative Penetration (ng/cm<sup>2</sup>)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	0	13	0	16	0
40	3	43	0	46	0
70	7	73	0	76	0
100	7	103	0	106	0
130	7	133	0	136	0
160	7	163	0	166	0
190	7	193	0	196	0
220	7	223	0	226	0
250	7	253	0	256	0
280	7	283	0	286	0
310	7	313	0	316	0
340	7	343	0	346	2
370	7	373	0	376	6
400	7	403	0	406	10
430	7	433	0	436	15
460	7	463	0	466	20
490	7	493	0	496	24
520	7	523	0	526	29
550	7	553	0	556	34
580	7	583	0	586	39
610	7	613	0	616	44
640	7	643	0	646	49
670	7	673	0	676	55
700	7	703	0	706	60
730	7	733	0	736	66
760	7	763	0	766	72
790	7	793	0	796	78
820	7	823	0	826	84
850	7	853	0	856	90
880	7	883	2	886	97
910	7	913	7	916	104
940	7	943	12	946	112
970	7	973	17	976	119
1000	9	1003	23	1006	128
1030	14	1033	30	1036	136
1060	19	1063	37	1066	145
1090	24	1093	45	1096	155
1120	30	1123	55	1126	165
1150	37	1153	65	1156	176
1180	45	1183	76	1186	188
1210	53	1213	88	1216	200
1240	63	1243	101	1246	213
1270	73	1273	115	1276	227
1300	84	1303	130	1306	241
1330	95	1333	146	1336	256
1360	108	1363	163	1366	271
1390	121	1393	181	1396	287
1420	135	1423	199	1426	304

Note: HD caused material to swell (raised bumps) where droplets were placed.

## Appendix B

**Blank**

## **APPENDIX C**

### **GB TABLES**

**Table C-1. ILC Chemturiion Suit Material vs. GB Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 9 Feb 98**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	0	7	0
31	0	34	0	37	0
61	0	64	0	67	0
91	0	94	0	97	0
121	0	124	0	127	0
151	0	154	0	157	0
181	0	184	0	187	0
211	0	214	0	217	0
241	0	244	0	247	0
271	0	274	0	277	0
301	0	304	0	307	0
331	0	334	0	337	0
361	2	364	0	367	0
391	7	394	3	397	3
421	15	424	10	427	11
451	30	454	23	457	25
481	53	484	45	487	47
511	86	514	76	517	78
541	131	544	119	547	120
571	186	574	174	577	172
601	250	604	238	607	233
631	322	634	310	637	303
661	402	664	390	667	381
691	490	694	479	697	468
721	583	724	577	727	562
751	685	754	684	757	664
781	794	784	799	787	773
811	910	814	920	817	889
841	1035	844	1051	847	1013
871	1167	874	1189	877	1144
901	1304	904	1333	907	1284
931	1447	934	1483	937	1428
961	1592	964	1639	967	1574
991	1742	994	1799	997	1727
1021	1897	1024	1964	1027	1887
1051	2058	1054	2136	1057	2051
1081	2224	1084	2315	1087	2221
1111	2393	1114	2500	1117	2395
1141	2564	1144	2687	1147	2574
1171	2737	1174	2878	1177	2757
1201	2916	1204	3072	1207	2941
1231	3098	1234	3268	1237	3130
1261	3284	1264	3469	1267	3324
1291	3475	1294	3674	1297	3524
1321	3668	1324	3883	1327	3730
1351	3868	1354	4101	1357	3944
1381	4079	1384	4327	1387	4165
1411	4301	1414	4565	1417	4397

## Appendix C

**Table C-2. ILC Chemturiion Suit Seam vs. GB Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 9 Feb 98**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	0	13	0	16	0
40	0	43	456	46	47
70	0	73	1113	76	109
100	0	103	1477	106	134
130	0	133	1800	136	152
160	0	163	2109	166	168
190	0	193	2407	196	182
220	0	223	2698	226	196
250	0	253	2981	256	208
280	0	283	3252	286	220
310	0	313	3517	316	231
340	0	343	3778	346	242
370	0	373	4029	376	252
400	0	403	4276	406	264
430	2	433	4518	436	276
460	8	463	4753	466	292
490	17	493	4985	496	311
520	29	523	5213	526	335
550	47	553	5438	556	365
580	71	583	5660	586	400
610	100	613	5878	616	441
640	134	643	6095	646	487
670	174	673	6312	676	540
700	220	703	6531	706	599
730	272	733	6752	736	665
760	331	763	6976	766	737
790	397	793	7202	796	816
820	471	823	7430	826	901
850	552	853	7663	856	994
880	638	883	7898	886	1092
910	731	913	8134	916	1196
940	829	943	8371	946	1306
970	930	973	8609	976	1421
1000	1038	1003	8850	1006	1543
1030	1153	1033	9095	1036	1671
1060	1275	1063	9343	1066	1803
1090	1404	1093	9595	1096	1941
1120	1536	1123	9846	1126	2083
1150	1673	1153	10097	1156	2229
1180	1815	1183	10349	1186	2381
1210	1961	1213	10603	1216	2537
1240	2113	1243	10857	1246	2697
1270	2269	1273	11114	1276	2862
1300	2428	1303	11375	1306	3032
1330	2595	1333	11641	1336	3209
1360	2769	1363	11911	1366	3392
1390	2952	1393	12186	1396	3584
1420	3149	1423	12472	1426	3791

## Appendix C

Table C-3. ILC Chemturon Outer Zipper Material vs. GB Liquid, 10 g/m<sup>2</sup>

Modified Static Diffusion Test, 11 Feb 98

Cumulative Penetration (ng/cm<sup>2</sup>)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	1	13	1	16	1
40	20	43	7	46	10
70	98	73	20	76	25
100	263	103	45	106	45
130	477	133	76	136	65
160	686	163	106	166	84
190	877	193	133	196	100
220	1054	223	158	226	115
250	1220	253	181	256	128
280	1377	283	202	286	140
310	1523	313	222	316	151
340	1660	343	240	346	161
370	1789	373	257	376	170
400	1912	403	273	406	179
430	2029	433	288	436	188
460	2139	463	302	466	196
490	2245	493	315	496	204
520	2346	523	329	526	212
550	2447	553	341	556	219
580	2546	583	354	586	226
610	2641	613	367	616	233
640	2733	643	379	646	240
670	2823	673	391	676	247
700	2910	703	403	706	253
730	2996	733	415	736	260
760	3080	763	426	766	267
790	3164	793	439	796	273
820	3245	823	451	826	280
850	3323	853	463	856	286
880	3400	883	476	886	293
910	3476	913	489	916	300
940	3549	943	502	946	306
970	3620	973	515	976	313
1000	3690	1003	529	1006	321
1030	3758	1033	544	1036	328
1060	3824	1063	559	1066	336
1090	3890	1093	576	1096	344
1120	3956	1123	594	1126	353
1150	4022	1153	612	1156	362
1180	4089	1183	632	1186	372
1210	4155	1213	654	1216	383
1240	4220	1243	676	1246	394
1270	4285	1273	701	1276	406
1300	4351	1303	728	1306	419
1330	4416	1333	757	1336	433
1360	4484	1363	789	1366	448
1390	4555	1393	824	1396	465
1420	4624	1423	861	1426	483

## Appendix C

**Table C-4. ILC Chemturon Zipper/Material Interface vs. GB Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 11 Feb 98**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	0	7	1
31	278	34	481	37	168
61	953	64	1445	67	814
91	1732	94	2416	97	1776
121	2469	124	3393	127	2739
151	3165	154	4341	157	3705
181	3820	184	5229	187	4673
211	4426	214	6055	217	5642
241	4995	244	6832	247	6612
271	5536	274	7565	277	7580
301	6041	304	8253	307	8546
331	6520	334	8905	337	9511
361	6979	364	9523	367	10479
391	7417	394	10109	397	11449
421	7837	424	10668	427	12422
451	8241	454	11206	457	13399
481	8632	484	11722	487	14379
511	9016	514	12219	517	15364
541	9397	544	12699	547	16352
571	9781	574	13174	577	17340
601	10159	604	13645	607	18328
631	10531	634	14106	637	19304
661	10902	664	14557	667	20258
691	11270	694	14992	697	21187
721	11637	724	15418	727	22097
751	12000	754	15839	757	22995
781	12363	784	16254	787	23886
811	12723	814	16658	817	24756
841	13079	844	17051	847	25593
871	13433	874	17436	877	26411
901	13785	904	17815	907	27217
931	14134	934	18192	937	28015
961	14484	964	18570	967	28809
991	14830	994	18946	997	29586
1021	15173	1024	19318	1027	30341
1051	15515	1054	19689	1057	31079
1081	15857	1084	20059	1087	31805
1111	16199	1114	20429	1117	32531
1141	16542	1144	20798	1147	33249
1171	16885	1174	21167	1177	33960
1201	17225	1204	21537	1207	34661
1231	17565	1234	21906	1237	35358
1261	17905	1264	22275	1267	36057
1291	18246	1294	22644	1297	36746
1321	18588	1324	23014	1327	37427
1351	18934	1354	23385	1357	38114
1381	19283	1384	23757	1387	38805
1411	19635	1414	24131	1417	39493

## Appendix C

**Table C-5. ILC Chemturiion Visor Material vs. GB Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 10 Feb 98**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	0	7	0
31	0	34	0	37	0
61	0	64	0	67	0
91	0	94	0	97	0
121	0	124	0	127	0
151	0	154	0	157	0
181	0	184	0	187	0
211	0	214	0	217	0
241	0	244	0	247	0
271	0	274	0	277	0
301	0	304	0	307	0
331	0	334	0	337	0
361	0	364	0	367	0
391	0	394	0	397	0
421	0	424	0	427	0
451	0	454	0	457	0
481	0	484	0	487	0
511	0	514	0	517	0
541	0	544	0	547	0
571	0	574	0	577	0
601	0	604	0	607	0
631	0	634	0	637	0
661	0	664	0	667	0
691	0	694	0	697	0
721	0	724	0	727	0
751	0	754	0	757	0
781	0	784	0	787	0
811	0	814	0	817	0
841	0	844	0	847	0
871	0	874	0	877	0
901	0	904	0	907	0
931	0	934	0	937	0
961	0	964	0	967	0
991	0	994	0	997	0
1021	0	1024	0	1027	0
1051	0	1054	0	1057	0
1081	0	1084	0	1087	0
1111	0	1114	0	1117	0
1141	0	1144	0	1147	0
1171	0	1174	0	1177	0
1201	0	1204	0	1207	0
1231	0	1234	0	1237	0
1261	0	1264	0	1267	0
1291	0	1294	0	1297	0
1321	0	1324	0	1327	0
1351	0	1354	0	1357	0
1381	0	1384	0	1387	0
1411	0	1414	0	1417	0

## Appendix C

**Table C-6. ILC Chemturon Suit/Visor Interface vs. GB Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 10 Feb 98**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	0	13	0	16	0
40	179	43	12	46	124
70	726	73	53	76	421
100	1498	103	116	106	786
130	2323	133	184	136	1187
160	3162	163	255	166	1606
190	3998	193	326	196	2058
220	4831	223	395	226	2543
250	5650	253	462	256	3043
280	6451	283	529	286	3555
310	7229	313	594	316	4066
340	7987	343	657	346	4566
370	8723	373	718	376	5051
400	9419	403	775	406	5515
430	10093	433	831	436	5969
460	10749	463	885	466	6416
490	11376	493	937	496	6842
520	11976	523	988	526	7244
550	12552	553	1036	556	7628
580	13109	583	1082	586	8000
610	13651	613	1128	616	8360
640	14180	643	1171	646	8711
670	14691	673	1212	676	9058
700	15180	703	1253	706	9403
730	15657	733	1292	736	9745
760	16129	763	1331	766	10085
790	16594	793	1370	796	10423
820	17042	823	1408	826	10761
850	17481	853	1447	856	11096
880	17914	883	1486	886	11428
910	18341	913	1525	916	11760
940	18764	943	1564	946	12090
970	19177	973	1604	976	12417
1000	19585	1003	1644	1006	12744
1030	19989	1033	1685	1036	13069
1060	20391	1063	1727	1066	13393
1090	20789	1093	1770	1096	13717
1120	21189	1123	1812	1126	14038
1150	21583	1153	1856	1156	14357
1180	21971	1183	1900	1186	14675
1210	22362	1213	1948	1216	14997
1240	22751	1243	1998	1246	15320
1270	23139	1273	2051	1276	15645
1300	23524	1303	2106	1306	15970
1330	23911	1333	2164	1336	16295
1360	24292	1363	2222	1366	16620
1390	24669	1393	2284	1396	16946
1420	25057	1423	2350	1426	17273

## Appendix C